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University of Maine.

Maine Agricultural Experiment Station

ORONO

BULLETIN No. 216. SEPTEMBER, 1913

POULTRY NOTES 1911-1913.

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BULLETIN No. 216.

POULTRY NOTES 1911-1913.

By Raymond Pearl.

The purpose of this bulletin is twofold. Its first object is to present descriptions of new methods of management, appliances, etc., which have been put into operation on the Station poultry plant, and found to be useful and practical for poultrymen in general. In connection with the investigations in breeding, which constitute the chief work of the Station with poultry, constant effort is made to discover better methods of managing and caring for the birds at all stages of their life history. The results of these practical studies and tests have no place in the reports of the scientific work on breeding. Therefore they are provided for in these Poultry Notes.

The second purpose of this bulletin is to present in brief abstract and in popular form the results of such technical studies on poultry as have not been, and will not be, published in other bulletins from the Station. The original technical reports are published in full in various scientific journals. They are not available for distribution by the Station.

The Value, Method of Preservation, and Economical Use of Hen Manure.

One of the most valuable by-products of any live-stock industry is the manure. Its proper care and use is one of the distinguishing features of a successful stock farm. The high nitrogen content of poultry droppings makes them in certain respects the most valuable of farm manures. At the same time this quality necessitates special treatment to preserve the nitrogen and utilize it economically.

According to experiments carried on at this Station some years ago* the night droppings average 30 pounds per hen per year.

*Woods C. D. and Bartlett, J. M. Ann. Rept. Me. Agr. Expt. Sta. 1903, pp. 199-204.

They contain .8 pound of organic nitrogen, .5 pound of phosphoric acid and .25 pound of potash. At the present price of fertilizers this material would be worth about 20 cents. No data are available on the amount of day-voided dung. Since the hens spend less than one-half their time on the roosts, and since more dung is voided while the birds are exercising than when at roost, the authors estimate that during a year probably 45 pounds of dung are voided by each bird while off the roost. Allowing that more than one-half of the fertilizing elements of the day dung are necessarily lost, the value of the total droppings, if properly cared for, should be at least 30 cents per bird per year

The poultryman or farmer who properly cares for the droppings can add a neat further profit to his business. For example the droppings from 1000 birds, if preserved without needless loss, will be worth at least $300.

Poultry manure contains more nitrogen than other farm manure, because in birds the excretion of the kidneys is voided in solid form (uric acid), with the undigested portions of the food. This form of nitrogen is easily available to plants. Unfortunately, however, it is not stable. Putrifactive processes easily change it to ammonia compounds, and unless special care is taken of the droppings one-third to one-half of the nitrogen passes off as ammonia gas.

The mechanical condition of poultry manure is poor. As Storer* says: "It is apt to be sticky when fresh and lumpy when dry." On this account, if used untreated, it can only be successfully applied to the land by hand, as it does not work well in drills or spreaders. Hen manure used alone is very wasteful of nitrogen as it carries this element in too large a proportion to its phosphorus and potassium.

In the experiments referred to above the problem undertaken by Woods and Bartlett was the determination of a method of treatment of hen manure which would first prevent the loss of nitrogen; second, add sufficient phosphorus and potassium in forms available for plant food to make a balanced fertilizer; and third, so improve the mechanical condition of the dung that it can be applied to the land with a manure spreader. Seven

*Storer, F. H. Agriculture in Some of its Relations with Chemistry. Chas. Scribner's Sons, New York, 1899, Vol. 1.

different methods of treatment were tested. The authors give the following summary of their results.

"By itself, hen dung is a one-sided nitrogenous fertilizer. As usually managed, one-half or more of its nitrogen is lost, so that as ordinarily used it does not carry so great an excess of nitrogen. Because of its excess of nitrogen it will be much more economically used in connection with manures carrying phosphoric acid and potash. As both acid phosphate and kainit prevent the loss of nitrogen, it is possible to use them in connection with sawdust or some other dry material as an absorbent (good dry loam or peat will answer nicely) so as to make a well balanced fertilizer. For example, a mixture of 30 pounds of hen manure, 10 pounds of sawdust, 16 pounds of acid phosphate, and 8 pounds of kainit would carry about .25 per cent nitrogen, 4.5 per cent phosphoric acid, and 2 per cent potash, which, used at the rate of 2 tons per acre, would furnish 50 pounds nitrogen, 185 pounds phosphoric acid, and 80 pounds potash."

At the present price of fertilizing ingredients this mixture is worth about $10.00 per ton. It is a well balanced, stable, fertilizer which, while still not fine enough to work well in drills, can be successfully applied with a manure spreader.

The kind of absorbent used should be the one which can be obtained at least cost, since the amount of plant food added by any of those suggested is negligible, and since they are about equally effective as dryers (the slight acidity of peat gives it some advantage as it helps a little to preserve the nitrogen). It is probably that one of the three can be obtained by any poultryman or farmer at little or no expense.

The absorbent and the acid phosphate and kainit should be kept conveniently at hand and each day when the droppings are collected they should be treated. It may be best to weigh the ingredients a few times, after which it will be possible to make sufficiently close estimates by measure.

The treated droppings should be well sheltered until time to apply them to the land, i. e., shortly before plowing. Any form of shelter may be used. For a temporary plant, or for a small farm, a small wooden building or a bin in a larger building will probably be the best place practicable; but for a large, permanent poultry plant a cement manure shed or tank is advisable.

A general farmer also will find such an equipment for the storage of all farm manure a paying investment. A portion of this shed can be partitioned off for hen manure.

A properly constructed cement building will not have to be constantly repaired and frequently replaced like a wooden structure, which rots out quickly when used for the storage of manure. The cement building is water tight, preventing the entrance of water from without and the escape of any unabsorbed liquid manure. It is, in fact, a perfect permanent shelter.

The New Maine Station Manure Shed.

Last fall (October 1912) this Station built at its poultry plant a manure shed large enough to accommodate the droppings from one thousand adult birds, over a period of a year, and the droppings collected from the range where about three thousand chicks are annually reared.

The inside measurements of this shed are 12x7 feet. It is 5 feet high at the eaves and 8 feet 2 inches to the peak of the roof. It is illustrated in figures 58 and 59.

The droppings are thrown into the shed through trap doors in the roof, and taken out from one end, which is of removable plank. The other three walls, and enough of this end wall to form the grooves which hold the ends of the planks; the floor; and the foundation are formed of one continuous cement mass (monolithic construction). The gables are board. The gable at the open (plank) end of the shed is removable to give more head room, when shoveling the manure into carts. It is held in place by hooks.

It was necessary to place this building on a very heavy clay soil which heaves badly with frost. For this reason it was placed on a much deeper foundation than would be necessary in a more favorable location. The foundation is a solid block of cement and rock, the size of the outside measurements of the shed and extending five feet below the surface of the ground. It was made by using as many rocks and as little cement as was consistent with the formation of a firm solid mass. For a few inches near the top, however, clear cement was used and this was smoothed off at ground level to form the floor. At the edges of this foundation the cement was continued up into the

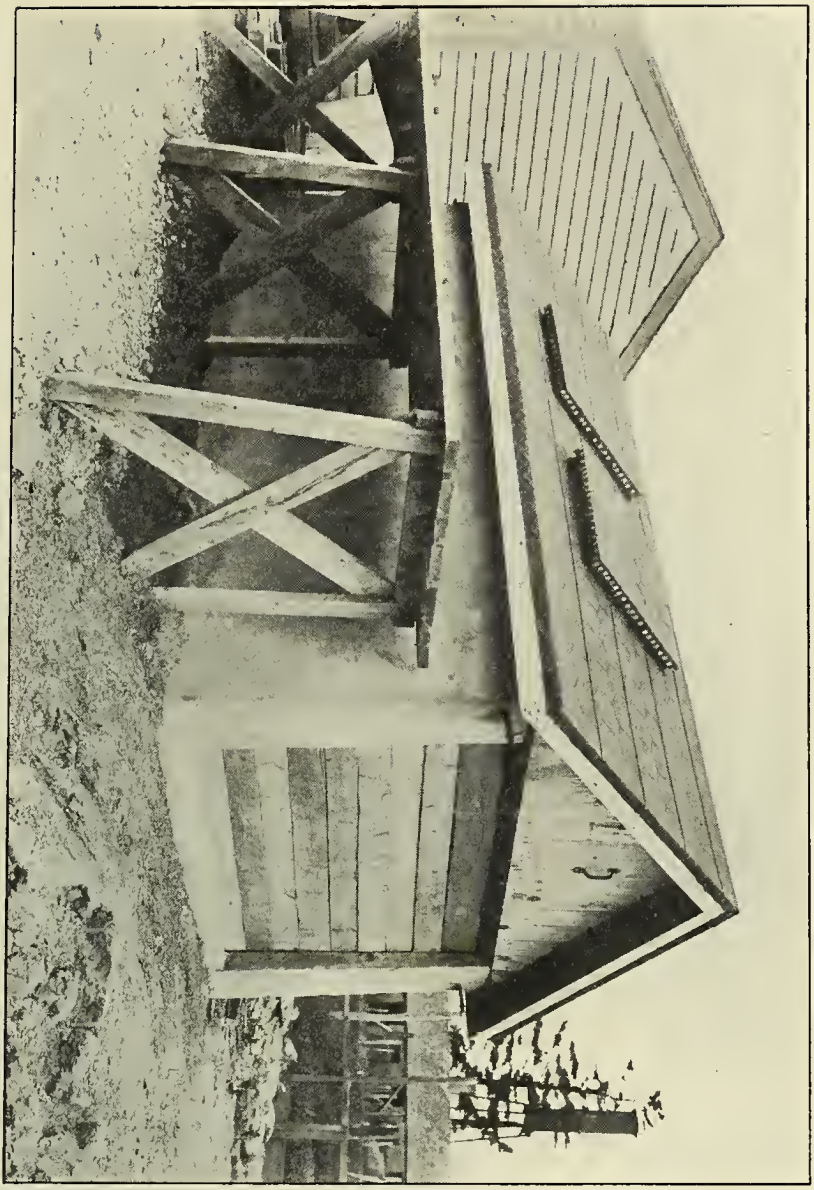

Fig. 58. Photograph of manure shed on poultry plant of Maine Agricultural Experiment Station. Note walk, trap-doors in roof, plank end, and removable gable.

wall forms which were built so that the walls are ten inches thick at the base and six at the top.

An iron bar ending in a ring was set in the cement near the top of the wall at each corner of the building. These rings project a few inches from the end walls. The roof is firmly secured to the walls by bolts passing through it and through these rings.*

*This is an awkward and unnecessary arrangement, and was only used through a misunderstanding on the part of the builder.

As stated above the larger part of one end of the shed is plank. The cement wall is continued on this end only far enough from either corner to provide a place for the slot into which the planks are slipped. This slot is formed by a groove two inches deep and a little more than two inches wide in each end of the cement wall. See Figs. 58 and 59. These grooves were formed by placing angle iron posts within the board forms.

This completes the description of the cement work in the building.

The removable end is of two inch planks which are slipped into the above described slot in the cement wall.

The plates and rafters are of 2x4 timbers. Inch boards were used for roof boards, gables, etc. The gable on the plank end is removable. It is held in position by hooks and is provided with a handle in the center.

The roof is covered with roofing paper. In one side are two trap doors also covered with this roofing. Each of these doors is 2 feet 4 inches x 2 feet 10 inches and fits over a frame in the roof, to which it is hinged at the top. The end of a lath is attached by a double screweye hinge to the inside of each door at the right edge about half way from bottom to top. The edge of this lath is provided with notches which hook over a nail on the inside of the door frame. When hooked this lath holds the door open. A 2x4 strip is nailed across the inside of each door frame a little more than half way from bottom to top. This serves as a rest for the basket when droppings are emptied into the shed.

This shed is placed at the end of the line of poultry houses. The wide raised walk which extends along the entire front of the houses is continued past the shed as a 2-foot walk. Between the last poultry house and the shed the walk is built on an incline so that at the end of the shed it is only 1 foot 8 inches from the eaves. This is a convenient height from which to reach the doors with the baskets of droppings.

The Cost of the Shed.

The itemized cost of this shed is as follows:

Cement	$15.60
Gravel	20.00
Inch boards	17.50

2x4 timber	13.00
2 in. plank	1.20
Finishings	10.00
Roofing	8.00
Labor	70.00
	$185.50

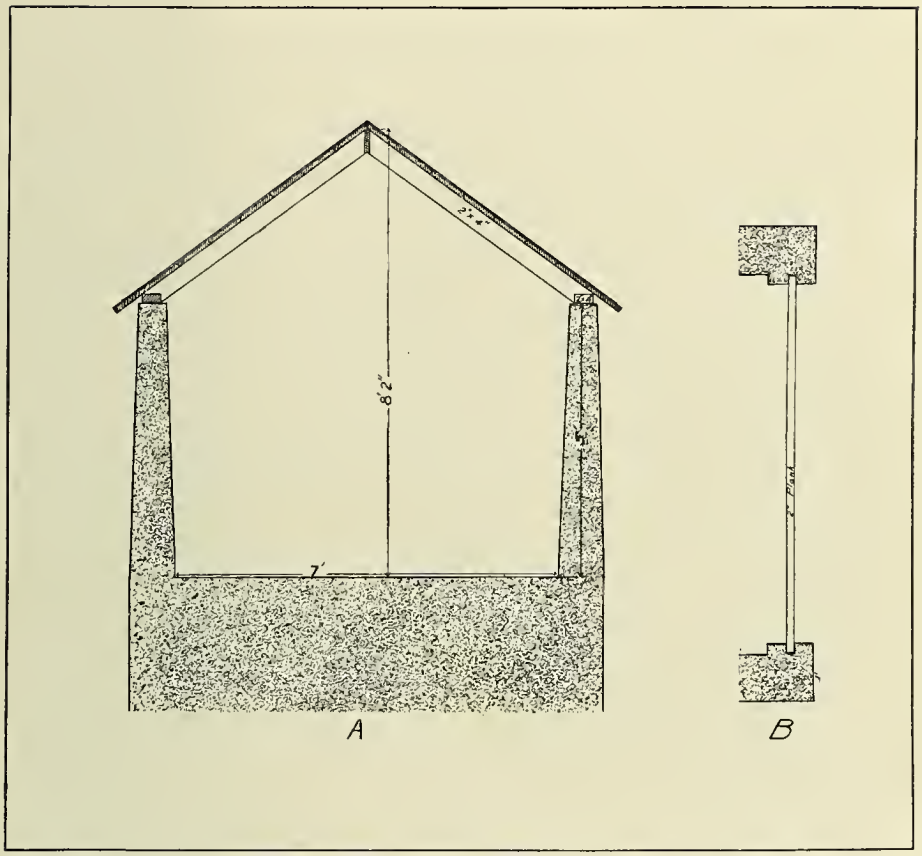

Fig. 59. *A*. Cross section of manure shed, showing dimensions and plan of construction. *B*. Horizontal section of front, showing planks in the grooves in the cement walls.

On many large poultry plants little or nothing is received for the manure. Probably few poultry plants save more than one-half the fertilizing elements possible, if proper methods of treatment and shelter were used. If the droppings are treated by the methods described above, and are kept properly sheltered,

the saving on any large poultry farm would in 1 to 3 years easily equal the cost of a permanent shed similar to the one here described.

A Crematory for Dead Poultry.

On every poultry plant and around every farm there are bound to occur from time to time a greater or less number of deaths of chickens and adult fowls from disease or other natural causes. The disposal of these dead bodies offers a problem to the poultryman, the correct solution of which may in many cases become a very important matter. This is especially true in the cases of death from contagious diseases, which include a considerable proportion of the deaths of poultry generally. The method usually practiced by the farmer and poultryman for the disposition of dead carcasses is insanitary in the extreme. To throw the dead bodies on the manure pile is to invite the spread of disease on the plant. Burying is far from being a satisfactory way of dealing with the matter for two reasons. Unless the grave is dug deep, which costs a good deal of time and labor, there is considerable likelihood that dogs or other marauding animals will dig out the carcasses, and, after feeding on them, scatter the remains around on the top of the ground. Furthermore, burying cannot be resorted to at all during the winter months when the ground is frozen.

The only really sanitary method of dealing with dead bodies is to incinerate them. The difficulty of following this plan in practice is that the farmer or poultryman usually does not have any suitable source of heat ready at hand at all times. To be sure, during certain seasons of the year, those poultrymen who employ large brooder houses with a hot water heating system have a furnace in operation, and the dead chicks can be burned up in the furnace. This, however, covers only a part of the year. At other times resort must be had to burying or some other means of disposal, as the poultryman is not likely to fire up a large furnace for the sake of burning a few dead birds.

At the Station plant it has been felt for some time that it was desirable to have a small crematory conveniently located, and so easy and economical of operation that dead birds could be disposed of immediately, with a minimum amount of trouble

and labor. To meet this requirement there has recently been devised the small crematory here described. The construction was carried out with the idea of keeping the first cost as low as possible, in order that there should be nothing about it which any poultryman or farmer could not easily afford to duplicate. As a matter of fact, the cost of materials for the crematory here described was less than ten dollars. The labor was done by the poultryman and his assistant at odd times, when an hour or two could be spared for this work. The result is, therefore, not beyond the reach of any poultryman or farmer. At the same time the crematory is so satisfactory in operation that anyone who builds one will wonder, after he has completed and used it for a time, why he did not long before have so simple and sanitary an adjunct to his plant.

The crematory shown in Figure 60 is very simple in construction. It consists essentially of a cement base or fire box, bearing on its top a series of grate bars which are in turn covered by a cremating box or oven in which the material to be incinerated is placed.

The crematory here described is sufficiently large to take care of all the needs of a plant carrying 1000 head of adult stock, raising 3000 to 4000 chickens annually, and in which a good deal of anatomical and physiological research is going on, necessitating a much larger amount of waste animal material than the ordinary commercial poultryman would have. Therefore, it is doubtful if it would be necessary in any but the very largest commercial plants to build a larger crematory than the one here described.

In building this an excavation was first made for the base, in which a lot of loose stones and gravel were placed, in order to secure adequate drainage below the cement. On top of this the cement base and fire box were made.

This base consists essentially of a rectangular box made of cement, open at the top, and with a small opening in front through which the fire is fed and which serves as a draught. The walls are about 6 inches thick. The outside dimensions of the fire box base are 3 feet, 4 inches by 2 feet, 6 inches. The inside dimensions of the fire box are 2 feet, 3 inches by 1 foot, 9 1-2 inches by 1 foot, 4 inches. Across the top of the fire box there were laid, while the cement was still soft, some old grate

bars from a small steam boiler, which had been discarded and thrown on the dump heap. These were set close together and held firmly in place when the cement hardened. They form the grate on which the material to be incinerated is thrown. These old boiler grate bars, besides costing nothing, had another advantage; namely that of their thickness and weight. When they become thoroughly heated from the fire below they will hold the heat for a considerable time charring and burning the animal material above.

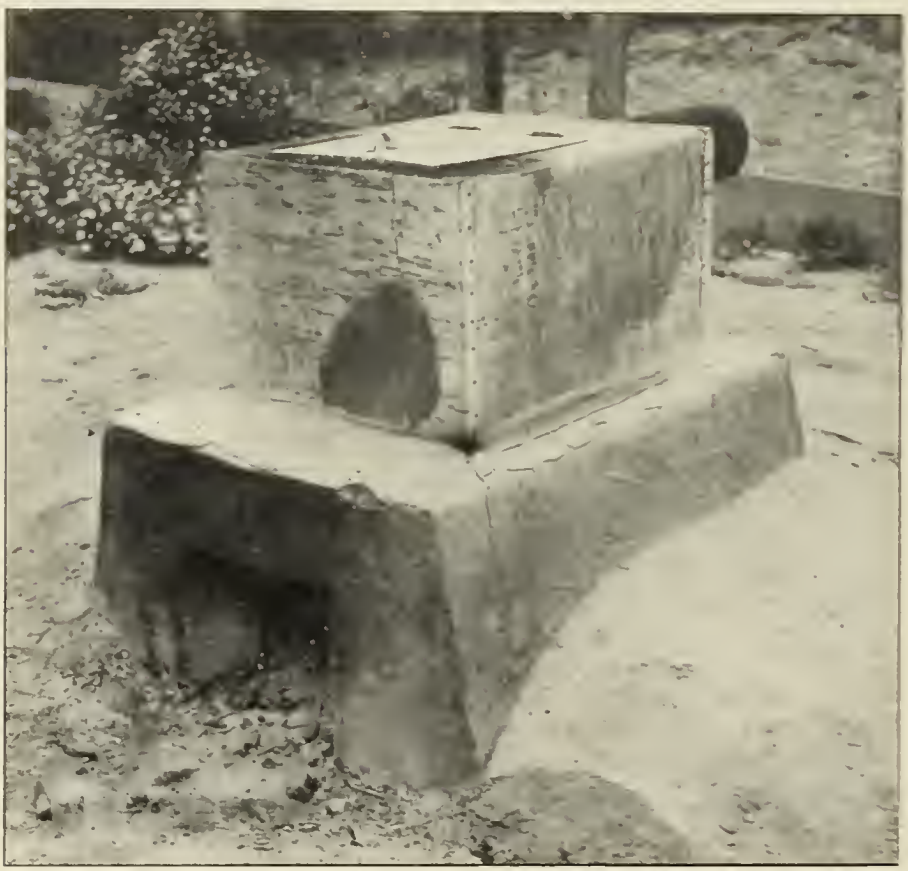

Fig. 60. Photograph of crematory described in text. Note cement base, with opening in front into fire box; galvanized iron cremating box on top; cover of cremating box.

The incinerating chamber proper was made from galvanized iron by a local tinsmith. This consists of a rectangular box having the following dimensions: Length 2 feet, 2 inches;

width 1 foot, 10 inches; height 1 foot, 6 inches. In the top of this is cut a round hole, 12 inches in diameter which is protected by a hinged cover 15 inches by 14 1-2 inches. This galvanized box has no bottom. It is placed on top of the grate bars, and held firmly in place by cement worked up around its lower edges. At the back end of this iron cremating box is an opening for a stove pipe, which is necessary in order to give the proper draught. It is found in practice that only a short piece of stove pipe is necessary to get sufficient draught to make a very hot fire, which entirely consumes the birds in a few hours. The funnel may best be left removable so that when the crematory is not in use it can be taken off and stored inside the wooden box, which then sets over the galvanized iron portion to protect it from the weather.

It is important in locating a crematory of this kind to plan matters so that there will be good drainage from around it. In particular pains should be taken to insure that water does not run into the firebox and freeze during the winter.

In operation the apparatus works as follows: Dead birds are thrown into the incinerating chamber through the opening in the top and the lid closed, while a wood fire is burning in the fire box below. The aim should be to use dry wood and get a quick and very hot fire. This first roasts the material and then chars it, and finally reduces it to fine ashes.

An Improved Range Feed Trough.

The type of slatted feed trough used here in feeding growing chickens on the range, and described in "Methods of Poultry Management at the Maine Stations" (Circular 471), is open to certain objections. It is very difficult to keep the grain dry in it in wet, stormy weather. Furthermore, the fact that very small chickens cannot use this type of trough entails additional labor. There must be flat boards with narrow rims for the very young chickens in addition to the range troughs for the older chicks. An improved range trough devised by the Station poultryman, Mr. Frank W. Tenney, obviates both of these disadvantages and has other points to recommend it. The essential features of this trough are shown in Figs. 61 to 63. The improvements consist, first, in making the slatted front of the

trough removable as a whole, leaving then a flat board bottom with a rail in front of it an inch high to hold the grain in place. With the slat front removed the trough duplicates the conditions of the flat chick feeding board, used by many poultry keepers for feeding chicks during the first two or three weeks of life. As the chicks grow older this slatted front can be put on the trough and held in place with the hooks and eyes shown in the photograph.

A second improvement consists in hinging the top rather than making it in one piece and removing as a whole, as was the case with the older feed troughs at this Station. It will be noted that this feed trough is open to the birds only from one side. The reason for this arrangement is that it is designed to place the feed troughs in holes cut in the longitudinal fences in the range yards, with the back part of the trough and the hinged cover extending into a long walk running the whole length of the range behind the yards. In this way the troughs can be filled from the outside without the necessity of going into the yard, opening gates, etc., thus reducing the labor cost of operation considerably.

Of course it is entirely possible to make troughs in accordance with the principle of this improvement, with removable slatted openings on both sides, to be set down in the middle of the yards so that the birds can get at the feed from both directions.

The dimensions of the troughs as used here are those given in the following table. It is, of course, not essential that these dimensions be absolutely followed in building feed troughs according to this principle, particularly the length dimensions. The dimensions of the boards forming the roof, however, and their angle, are of more or less importance since actual trial has shown that when built as here pictured and described the grain will keep dry in the trough even in driving showers or storms. A strip of canvas keeps the hinged joint of the roof dry.

Dimensions of Feed Trough.

Length	8	ft. 4	inches
Height to peak	1	" 6	"
Width at bottom		3	"
Width at widest point		6½	"
Height of front opening		12½	"
Width of roof boards (front and back same)		11	"

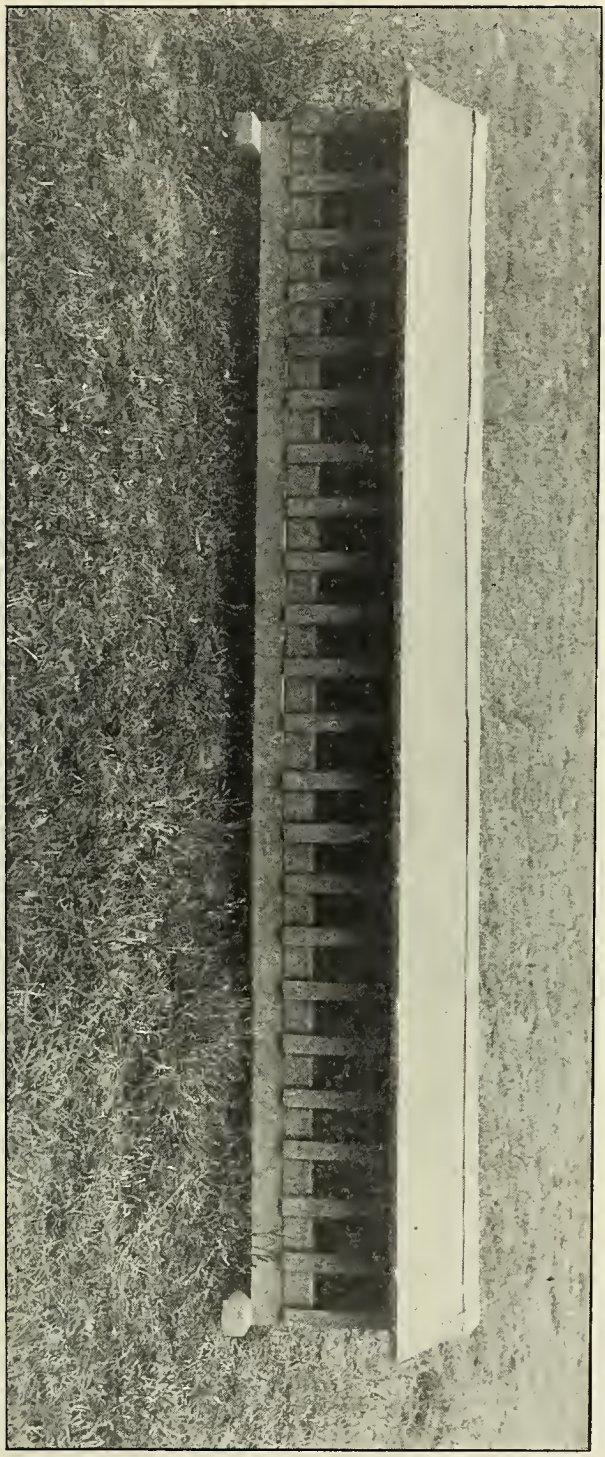

Fig. 61. Front view of feed trough, with slats in place. For large chickens.

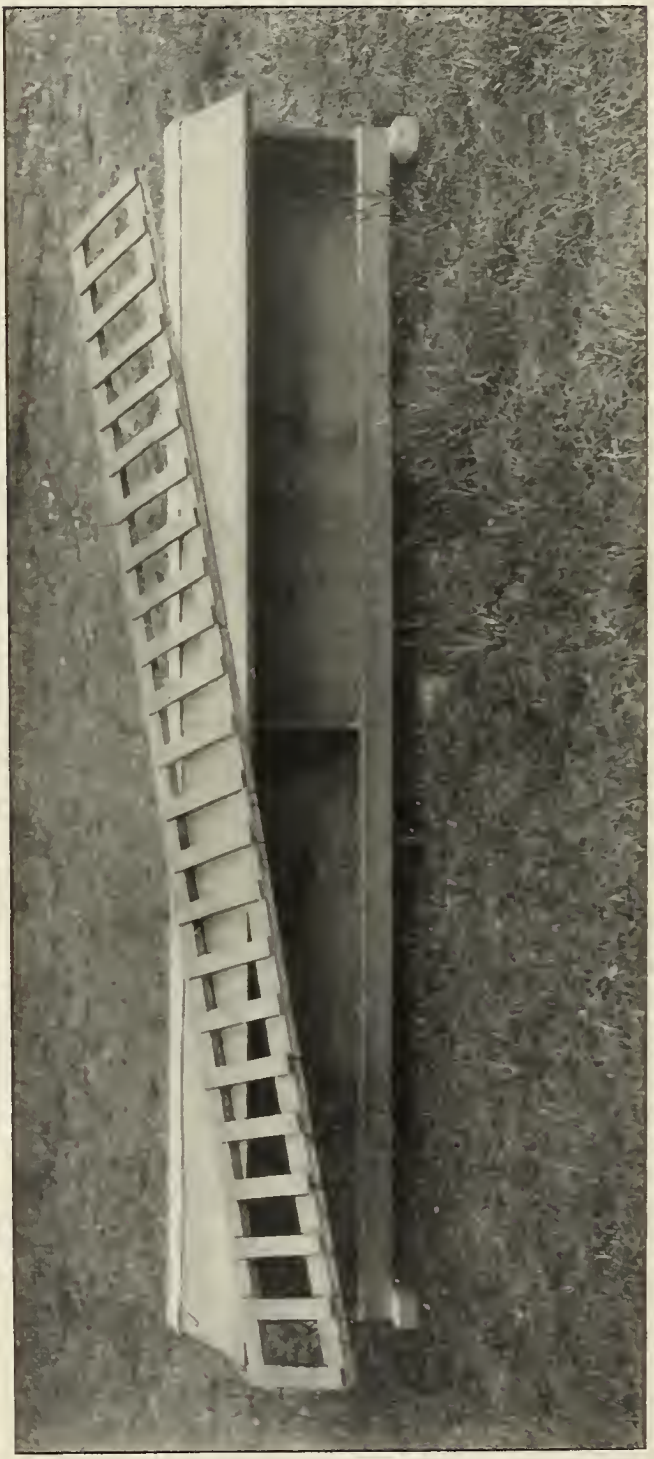

Fig. 62. Front view of feed trough with slats removed and laid across top. This trough is now in condition for the use of very small chicks.

Natural Enemies of Poultry.

One of the chief difficulties that the poultryman has to contend with is the continued loss of chicks, and sometimes even of nearly full grown birds, as a consequence of the depredations

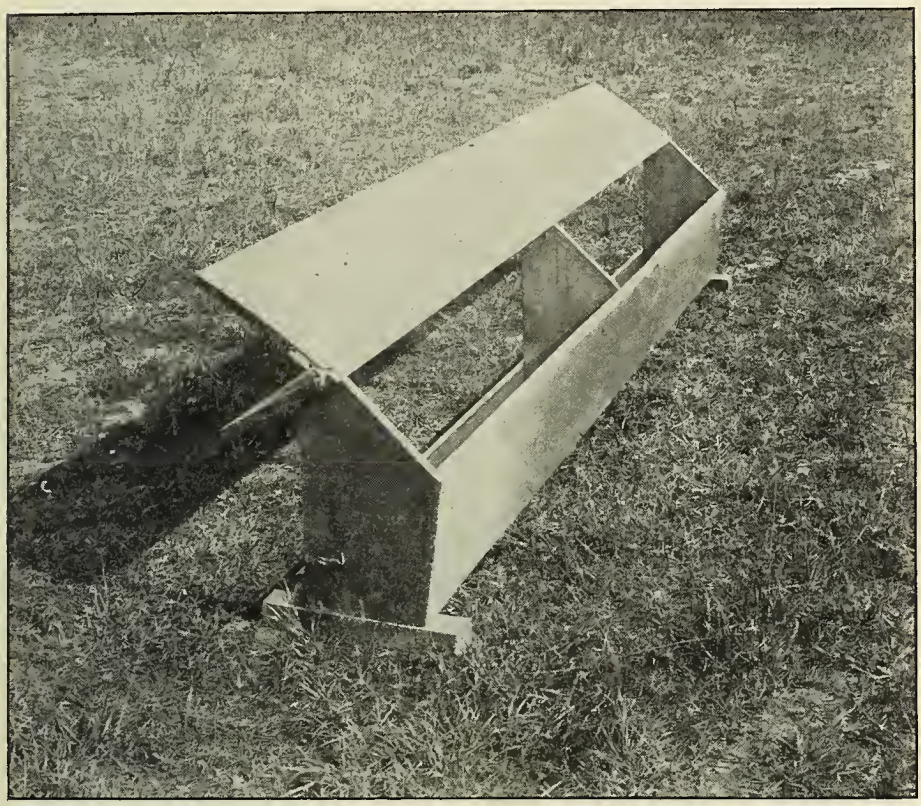

Fig. 63. End and top view of trough with cover open and slatted front removed. Note hook which holds front in place.

of natural enemies. It is safe to say that the magnitude of the loss from this source is not anything like fully realized by any one who has not kept an accurate account of all his birds. In the experimental breeding work with poultry at the Maine Station it is necessary to keep account of every bird on the plant. It has, therefore, on this account been possible to check up and form an adequate estimate of the losses due to the creatures that prey upon poultry. A good deal of attention has been devoted to the problem of how these losses may be cut

down and the results of this experience may be of benefit to other poultry keepers.

In the experience of this Station the most destructive natural enemy of poultry in the long run has been found to be the crow. The depredations of the hawks are more spectacular perhaps, but in the long run far less destructive. A hawk will only visit a poultry yard occasionally, and especially if he is shot at once or twice will be very wary about approaching it again. On the contrary the crow is a steady and persistent robber. He will continue his depredations just as long as it is physically possible for him to do so. While there may be some doubt as to whether crows are beneficial or harmful as regards other phases of agriculture, there can be no question that, so far as the poultry man is concerned, the only good crow is a dead one. For a number of years the crows killed and either carried away, or left behind partly eaten, a large number of chicks on the Station poultry plant. The losses were not by any means confined to the small chicks, but half grown birds, each nearly equal in weight to the crow itself, were killed, partly eaten, and left behind on the range.

One after another all the devices which had been suggested by others, or could be thought of by those in charge of the poultry work, were tried in order to stop these ravages. In a single year the crows destroyed something over 500 chicks. One important reason for these heavy losses is the location of our poultry range. It borders upon a pine forest in which the crows congregate in great numbers. In the case of a range farther from the woods the losses, without protection, would not be nearly so heavy. Various sorts of "scare-crows" were tried but with no effect whatever. Dead crows were hung up on stakes about the yards as solemn warnings to their fellows, but instead of operating as warnings they appeared rather to serve as "invitations to the dance." Decoying the birds in various ways so that they might be shot was tried, but with very slight individual success and no substantial effect on the steady losses. Poisoning is reported to have been used with success in other places, but has never been tried on the Station plant. It is doubtful whether it is justifiable, save under very exceptional circumstances. The point is that it is difficult to manage affairs in such way as to insure that only the crows

will get the poison. There are so many useful and valuable animals about the farm that easily might get the poison before the crow did, with a resulting loss greater than that caused by the crow, that it would seem wise to resort to poisoning only when it can be done under well controlled conditions.

The plan which has finally been adopted at the Station poultry plant for dealing with crows is one which is perfectly safe and sure in its operation. It consists simply in running strands of binder twine about two feet apart over the whole of the poultry range occupied by the young birds, until they reach such size that they are able to take care of themselves. These strings are run over the tops of the brooder houses, and on supports made by cross strands of either wire or two or three strings of binder twine twisted together. These cross strands are held up where necessary by posts. The whole network of strings thus formed is put at such height that the attendants in working about the yard, will not hit the string when standing upright. The area covered in with strings in this way on the Station poultry plant is usually about 3 acres per year. The expense of covering this area is from $15 to $20 for twine. The labor of putting it up is comparatively small. It forms a perfect and complete protection against both crows and hawks.

The appearance of the range when covered with strings is shown in figure 64.

Next in importance to the predaceous birds, as poultry enemies, stand the rats and the foxes. In times past foxes have destroyed many chickens from the Station's poultry plant. Of late years, however, none has been lost. The protection is afforded by a fox proof fence surrounding the whole plant. Rats may become a very serious pest. They live under the brooder houses and take the young chicks. Various methods have been tried at the Station, but no wholly satisfactory way of dealing with rats has yet been found. Trial was made some years ago of one of the most widely advertised of the bacterial rat destroyers, which when fed to rats is supposed to induce a disease which kills them all. No effect whatever was observed to follow the use of this preparation. The rats ate freely of grain which had been moistened with it and if any disease developed as a consequence it has not yet benefited us, or perceptibly inconvenienced the rats. Digging the rats out of their holes

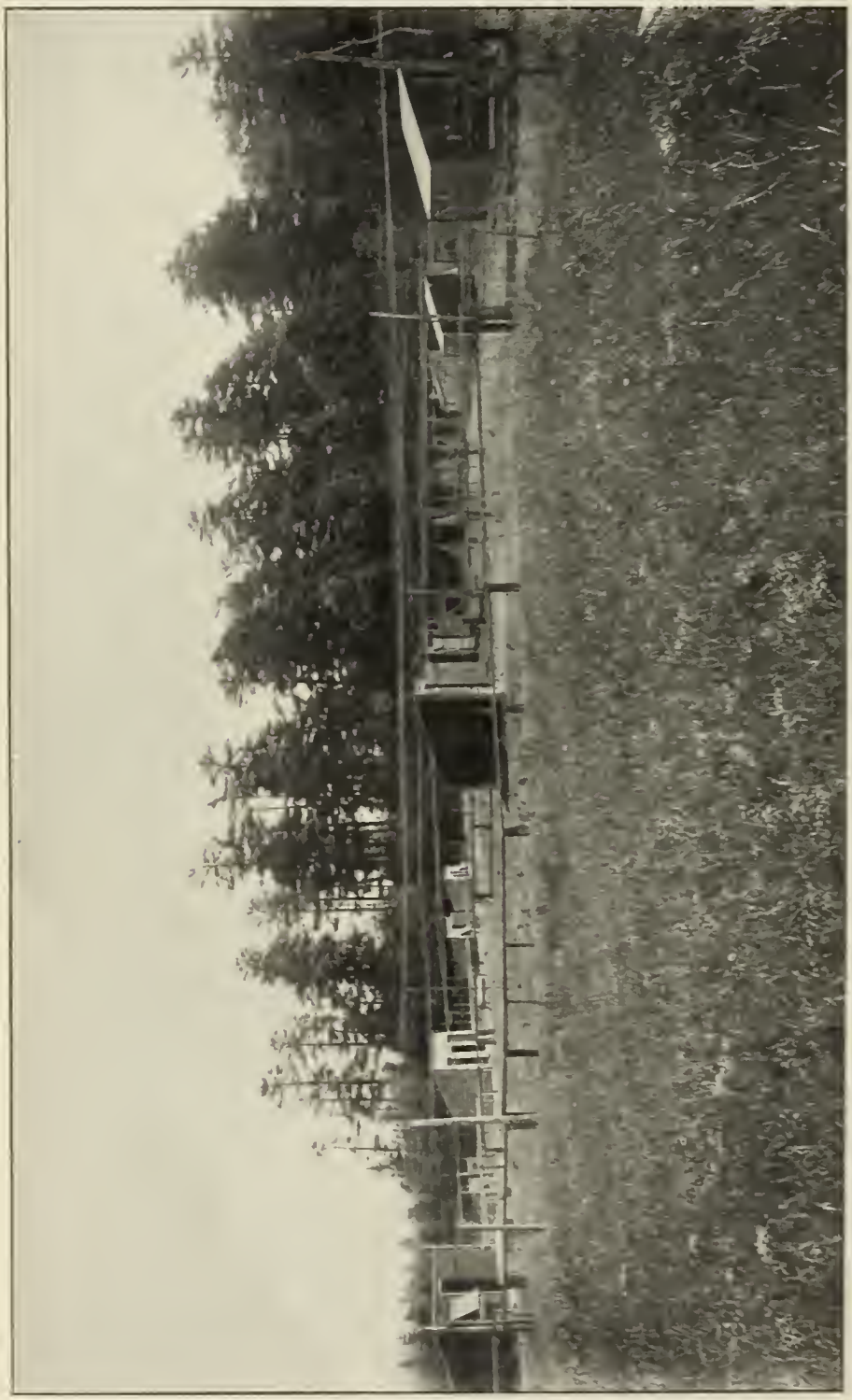

Fig. 64. Showing poultry range in 1913 covered with strings two feet apart, as a protection against crows and other predaceous birds.

and shooting them is one effectual method of dealing with them. Several good cats on the place also aid materially in fighting this pest. A systematic trapping campaign is productive of good results. It must, however, be continued without interruption over a considerable period of time. Desultory trapping produces little effect on the rat population. A thorough-going campaign, however, tends to drive the uncaught rats away from the premises.

Green Food for Poultry.

During recent years an increasing amount of attention has been paid by poultrymen everywhere to the furnishing of green food to their fowls during the winter months, when it is impossible, in northern parts of the country, at least, for the birds to get fresh succulent pasturage out of doors. General experience seems to teach that an addition of green succulent food to the ration of laying hens tends to keep them in better physical condition and helps towards a better egg production. On the poultry plant of the Maine Station considerable attention has been given to this matter of supplying green and succulent food and as a result of experience extending now over a number of years, a satisfactory scheme of furnishing this necessary part of the ration under our conditions has been worked out.

To be satisfactory not only must the green food given to poultry be of the proper kind to give good results in egg production, but also it must be something which can be produced and handled at small cost. Furthermore a factor which is frequently lost sight of is that fowls need something besides succulence in their so-called "green" food. There is a distinction between a succulent fodder and a "green food" in the strict sense. One can supply succulence in the form of root crops such as mangolds. A careful consideration of the case, however, indicates that apparently the fundamental need of the fowls is not for succulence as such, but rather for the tonic effect which is produced by green plants, probably primarily because of the presence of chlorophyll. In feeding fowls for high egg production it is neessary that they be given a ration rich in protein. Only fowls of strong constitution, and with thoroughly sound digestive systems, can handle the heavy laying rations carrying

meat scrap and oil meal, which are now so widely used by poultrymen for egg production with successful results. On these heavy rations there is always a tendency for the birds' livers to become impaired in function, and ultimately to become enlarged and diseased. As the matter has been studied here it would appear that one of the chief functions of green food in the ration is to counteract this tendency of the digestive system, and especially the liver, to break down under the strain of handling heavy laying rations over a long period of time. It would appear that the green food given to poultry acts primarily rather as a mild tonic than as a food in the proper sense. There seems to be very little of this tonic effect produced from succulent non-green foods like mangolds.

The practical problem then becomes to devise a system which shall insure a supply of green food for the birds at all seasons of the year. The following system of rotation in the green food supply has been in use for several years on the poultry plant here with satisfactory results. It should be said that, owing to the small area of ground available for the poultry work at the Station in relation to the number of birds it is necessary to carry, green food must be added to the ration practically throughout the year, not only for the adult fowls in the laying houses, but also for the chicks growing on the range.

Beginning in the early fall when the pullets are put in the laying house they are given green corn fodder cut fine in a fodder cutter. Stalks, leaves and ears are cut together in pieces averaging about 1-2 inch in length. The birds eat this chopped corn fodder greedily. It is one of the best green foods for poultry that we have yet been able to find. Its usefulness is limited only by the season within which it is possible to get it. The feeding of corn fodder is continued until the frost kills the plants.

When the corn can no longer be used cabbage is fed. The supply of this usually lasts through December. In the event of the supply of cabbage failing before it is desirable to start the oat sprouter* the interval is filled out by the use of mangolds. From about January 15 to May 15 green sprouted oats

*For description of the method of sprouting oats used at the Station see "Methods of Poultry Management at The Maine Agricultural Experiment Station." Circular 471, pp. 50-54.

from the source of green food. From about May 15 until the corn has grown enough to cut, fresh clover from the range is used. During the summer the growing chicks on the range are given rape (Dwarf Essex) and green corn fodder cut as described above, to supplement the grass of the range, which rather rapidly dries out and becomes worthless as a source of green food under our conditions. The very young chicks in the brooders are given the tops only of green sprouted oats chopped up fine.

Dwarf Essex rape is an excellent source of green food for poultry but it must be fed with great caution to birds which are laying because if eaten in any considerable amounts it will color the yolks of the eggs green, with disastrous results in the market.

Technical Studies on Poultry Already Published.

A considerable portion of the more technical scientific work of the department of biology of the Station, which has in charge the work with poultry, is published in current biological journals, not readily accessible to the agricultural public. It is the purpose of the present section of this bulletin to give briefly the essential points brought out in certain of these technical studies which have been published during the period covered by the present bulletin.

HOW THE WHITE OF THE EGG IS MADE.*

The oviduct of a laying hen is divided into five main parts, readily distinguishable by gross observation. Beginning at the anterior end of the organ these parts, in order, are: (a) the infundibulum, or funnel, (b) the albumen secreting portion,

*This is an abstract of a more extended paper by Raymond Pearl and Maynie R. Curtis having the title "Studies on the Physiology of Reproduction in the Domestic Fowl. V. Data regarding the Physiology of the Oviduct," published in the Journal of Exper. Zoölogy, Vol. 12, pp. 99-132. 1912.

(c) the isthmus (d) the uterus or "shell gland" and (e) the vagina. These parts are shown in Figure 65.

Each of these parts is generally supposed to play a particular and exclusive role in the formation of the protective and nutritive envelopes which surround the yolk in the complete egg as laid. Thus the funnel grasps the ovule at the time of ovulation; the glands of the albumen region secrete the different sorts of albumen (thick and thin) found in the egg; the shell membranes are secreted in the isthmus; and finally the glands of the uterine wall secrete the calcareous shell. This is in brief, the classical picture of the physiology of the oviduct.

For some years past experiments and observations have been systematically carried on in the Biological Laboratory of the Maine Station with the object of acquiring a more extended and precise knowledge of the physiology of the hen's oviduct than is to be gained from the literature. It is the purpose here to present a certain part of the results which have been obtained regarding the physiology of two of the lower divisions of the duct, namely the isthmus and the uterus. Our results indicate that these portions of the oviduct perform certain functions which have not hitherto been observed or described.

So far as the existing literature indicates, the opinion has been held by all who have worked upon the subject that the particular functional activity of each portion of the oviduct (as above described) is *limited* to that portion. Thus it is commonly held that when an egg in its passage down the oviduct leaves the albumen portion it has all the albumen it will ever have; when it leaves the isthmus it has all its shell membrane; and when it leaves the uterus all its shell. On this prevailing view there are in the albumen portion only albumen secreting glands, in the isthmus only membrane secreting glands, and in the uterus only shell secreting glands. The entire truthfulness of this assumption was first made doubtful by the observation, frequently made in connection with routine autopsy work, that (a) eggs in the isthmus with completely formed shell membranes, and (b) eggs in the uterus, bearing in addition to the complete shell membranes a partially formed shell, weighed considerably less than the normal average for laid Barred Plymouth Rock eggs. This observation led to an inquiry as to

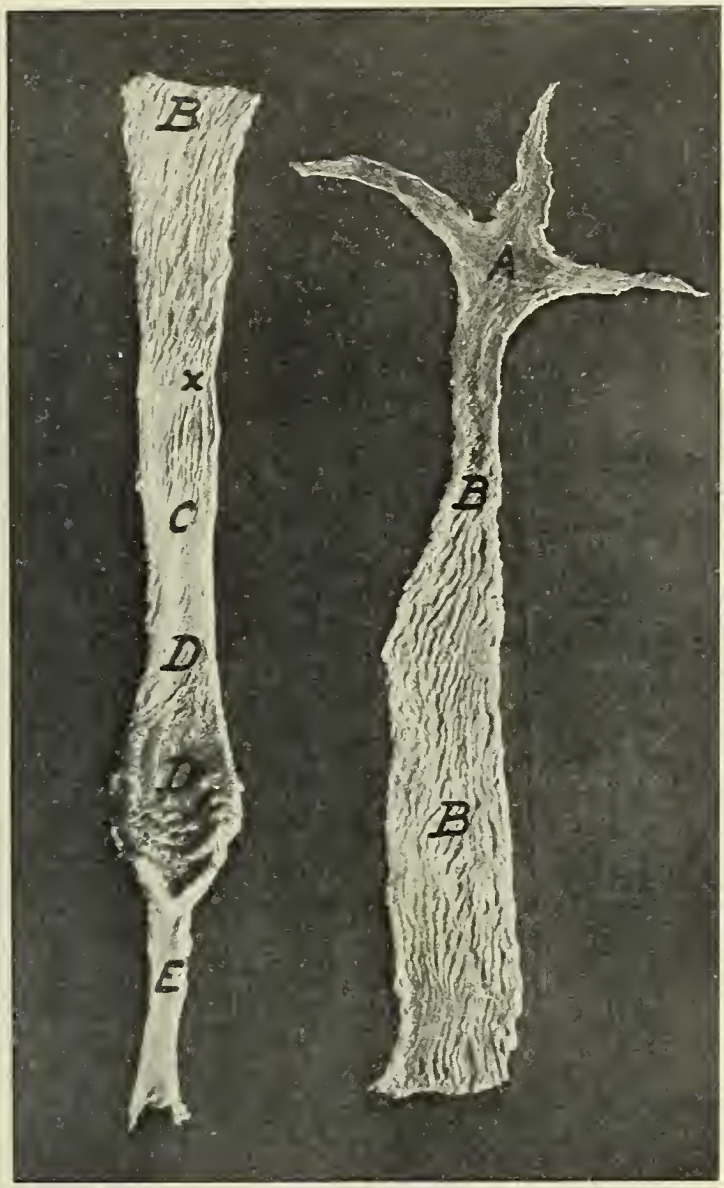

Fig. 65. Photograph of a hen's oviduct which has been removed, slit longitudinally throughout its length and opened out flat in order to show the gross anatomy. In order to get the whole duct on the photographic plate it was necessary to transect it at about the middle. *A*, the infundibulum. Note muscle fibers in wall and absence of any extensive gland development. *B*, albumen secreting portion; note heavy glandular development. The albumen portion ends and the isthmus begins at *x*. The line of demarcation is very distinct in the freshly prepared oviduct. *C*, the the isthmus. *D*, the uterus or shell gland. *E*, the vagina. About one-third natural size.

whether this apparently lower weight of presumably completed, but not laid eggs, as compared with those which has been laid, was a real phenomenon of general occurrence, and if so to what it was due. Does the egg increase in weight after the formation of shell membranes and shell merely by the absorption of water or by the actual addition of new albumen?

Observations and Experiments.

In the normal egg of the hen there are certainly three and possibly four different albumen layers which can easily be distinguished on the basis of physical consistency. These are: (*a*) the *chalaziferous layer*. This is a thin layer of very dense albuminous material which lies immediately outside the true yolk membrane. It is continuous at the poles of the yolk with the chalazæ, and is undoubtedly formed in connection with those structures. It is so thin a layer that it might well be, and often has been, taken for the yolk membrane. (*b*) The inner layer of *fluid* (thin) *albumen*. This layer is only a few millimeters in thickness and there is some doubt as to its existence as a separate distinct layer. (*c*) The *dense albumen*. This is the layer which makes up the bulk of the "white" of the egg. It is composed of a mass of dense closely interlaced albumen fibres with some thin albumen between the meshes of the fibrous network. The dense albumen as a whole will not flow readily but holds itself together in a flattened mass if poured out upon a plate. (*d*) the outer layer of *fluid albumen*. This is the principal layer of thin albumen, which makes up the fluid part of the "white" observed when an egg is broken.

In order to determine when and where these different layers were added to the egg, particularly the last one (*d*), hens having an egg in the oviduct were killed and the location and condition of the egg determined. Many such autopsy records agree in showing that *the egg does not receive the outer layer of thin fluid albumen (layer d) during its sojourn in the so-called albumen secreting portion of the oviduct.*

A single illustrative protocol may be cited here. *Autopsy No. 301.* Hen No. E. 39. July 14, 1909.

When this bird was killed an egg was found at the lower end of the albumen portion of the oviduct just about to enter the

isthmus. Not yet having entered the isthmus the egg had no shell membrane upon it. It consisted merely of a yolk surrounded by albumen. The outermost layer of this albumen was dense and corresponded to layer *c* described above. There was no trace of thin albumen (layer *d*) on this egg although it was just on the point of leaving the so-called albumen region of the oviduct.

The successive autopsy records reported in the complete paper show that beginning with an egg 11 cm. away in front of the isthmus and going downwards in the duct until the actual boundary of the isthmus is reached, there is no qualitative change in the albumen secretion. Whatever albumen is added to the egg immediately prior to the formation of the shell membrane, is of the dense fibrous variety (layer *c*), so far as direct observation indicates.

In cases where one-half of the egg lies within the isthmus and bears a membrane, while the other half is in the albumen portion and has no membrane, it can plainly be seen that *the shell membrane is deposited directly on the outer surface of the thick albumen (layer c) and that no trace of the thin albumen (layer d) is present at the time the membrane is formed.*

A detailed and careful study of the weights of the several parts of the egg (yolk, albumen, shell membranes) in eggs taken from different levels of the oviduct, leads to the following results.

When the egg leaves the albumen portion of the oviduct it weighs roughly only about a half as much as it does when it is laid. Nearly all of this difference is in the albumen. Thus these weighings fully confirm the conclusion reaches from direct examination of the eggs, as already described. The evidence shows that the egg gets all of its thin albumen (layer *d*), which constitutes nearly 60 per cent by weight of the total albumen, only *after* it has left the supposedly only albumen secreting portion of the oviduct, and has acquired a shell albumen, and the shell is in process of formation.

The weighings show that in general the farther down the oviduct the egg proceeds the more albumen it gets. Very nearly one-half the total weight of albumen of the completed egg is added in the uterus, an organ hitherto supposed to be entirely

devoted to shell formation Clearly much more albumen is added to the egg in the uterus than in the isthmus. This, of course, does not necessarily mean any more rapid rate of secretion in the uterus, because of the time element involved. The egg stays much longer in the uterus than in the isthmus.

The rate of albumen secretion per unit of time as the egg passed down the oviduct was determined, and was found to be expressed by a parabola,

$$y=17.5915x—.8171x—0.4164$$

in which y denotes percentage of albumen and x time in hours during which the egg has been in the oviduct. This relation is shown in Figure 66.

There is scarcely any diminution in the rate of secretion until nearly the total amount has been acquired by the egg. There is not the slightest evidence of any break in the rate of secretion of albumen after the egg leaves the so-called "albumen portion" of the duct. From the time the yolk enters the upper end of the "albumen portion" there is a gradual diminution of the rate of secretion of albumen, giving rise to the parabolic curve. But there is no sudden change. The egg gets more than half of its total albumen after it leaves the "albumen portion" of the duct and it takes this at nearly the same rate as it did the earlier part.

While the two lines of evidence already presented amply demonstrate that the "thin" albumen is added to the egg after it leaves the so-called albumen portion of the duct, it seemed advisable, because of the novelty of the results, to collect still further evidence of another kind. This evidence has to do with the nitrogen content of the albumen in eggs taken from different levels of the oviduct.

The point of greatest interest and importance in connection with these chemical data hinges upon the *absolute* amount of nitrogen in the albumen. Since it is solely the "thin" albumen layer which is added after the egg leaves the so-called albumen portion of the oviduct the possibility is at once suggested that what happens in the lower portions of the duct is not a true secretion of another albumen layer but merely a taking up of of water from the blood by osmosis, and a dilution or partial solution of the "thick" albumen already present. Such a view

assumes in other words that all that is added to the albumen after the egg enters the isthmus is water.

Clearly the only way to test finally the validity of this idea is to make chemical determinations. What the figures from the analyses show is that the oviduct egg *has absolutely less nitrogen in its albumen than the normal laid egg of the same hen.* This, of course, is what would be expected if there is an actual

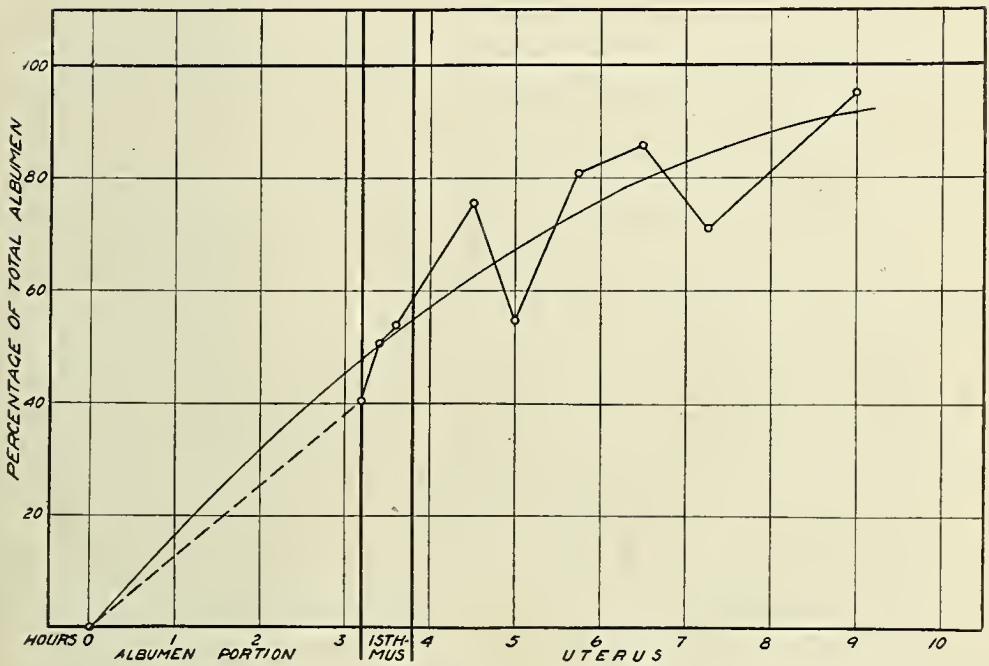

Fig. 66. Diagram showing what percentage of the total amount of albumen present in the normal laid egg is present at successive levels in the oviduct. The smooth curve is the parabola for which the equation is given in the text.

secretion of albumen by the glands of the isthmus and uterus, and this secretion is added to the egg. It means that these oviduct eggs have been removed before they received their full amount of albumen. If it were the case, on the contrary, that only water was added to the egg after it left the albumen portion of the duct, it would be expected that the amount of nitrogen would be the same in an oviduct egg from the isthmus or uterus as in the normal laid egg. *The chemical data clearly indicate that there is a definite addition of albumen to the egg in the isthmus and shell gland and that the "thin" layer does not represent solely a dilution of the "thick" layer.*

Summary of Results.

Putting all the evidence together the following account of the processes by which the hen's egg acquired its protective and nutritive coverings summarizes the results of the present study.

1. After entering the infundibulum the yolk remains in the so-called albumen portion of the oviduct about three hours and in this time acquires only about 40-50 per cent by weight of its total albumen, and not all of it as has hitherto been supposed.

2. During its sojourn in the infundibular and albumen portions of the duct the egg acquires its chalazæ and chalaziferous layer, and the "thick" albumen layer.

3. Upon entering the isthmus, in passing through which portion of the duct something under an hour's time is occupied instead of three hours as has been previously maintained, the egg receives its shell membrane by a process of discrete deposition.

4. At the same time, and during the sojourn of the egg in the uterus, it receives its outer layer fluid, or "thin" albumen which is by weight 50-60 per cent of the total albumen.

5. This "thin" albumen is taken in as a dilute fluid by osmosis through the shell membranes already formed. The fluid albumen added in this way diffuses into the dense albumen already present, dissolves some of the latter and so brings about its dilution in some degree. At the same time the fluid albumen is made more dense in this process of diffusion, and comes to have the consistency of the thin albumen layer of the normal laid egg. The fluid albumen taken into the egg by osmosis is a definite secretion of glands of the isthmus and uterus.

6. The addition of albumen to the egg is completed only after it has been in the uterus from 5 to 7 hours.

7. Before the acquisition of albumen by the egg is completed a fairly considerable amount of shell substance has been deposited on the shell membrane.

8. For the completion of the shell and the laying of the egg from 12 to 16, or exceptionally even more, hours are required.